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3-Dimensional imaging for lower third molars: is there an implication for surgical removal?

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Abstract: Three-dimensional imaging is useful for predicting the risk of postoperative IAN impairment before surgical removal of impacted lower third molars. The low IAN impairment rate seen in this study-compared with similar selected study groups in the literature of the era before 3D imaging-indicates that the availability of 3D information is actually decreasing the risk for IAN impairment after lower third molar removal.

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Three-dimensional imaging for lower third molars: Is there an implication for surgical removal?

Abstract

Introduction

Surgical removal of impacted third molars is maybe the most frequent procedure in oral surgery. Damage to the inferior alveolar nerve (IAN) is a typical complication of the procedure with incidence rates reported at between 1 and 22%. The aim of this study was to identify factors that lead to a higher risk of IAN impairment after surgery.

Method

A total of 515 surgical wisdom tooth removals having 3D imaging prior to surgical removal were retrospectively evaluated for IAN impairment, along with 3D imaging signs that were supposed predictors for postoperative IAN disturbance. Influence of each predictor was evaluated in univariate and multivariate analyses and reported as odds ratio (OR) with 95% confidence interval (CI).

Results

The overall IAN impairment rate seen in this study was 9.4%. Univariate analysis revealed narrowing of the IAN canal ($p < 0.0001$, OR=4.95), direct contact between IAN and root ($p = 0.0008$, OR=5.05), fully formed roots ($p = 0.045$, OR=4.36), an IAN lingual course with ($p = 0.0013$, OR=6.64) and without ($p = 0.007$, OR=2.72) perforation of the cortical plate, and an intra-root ($p = 0.003$, OR=9.96) position of the IAN as predictors of postoperative IAN impairment. Multivariate analysis revealed narrowing of IAN canal ($p = 0.0001$, adjusted OR=3.69, 95%CI 1.88 – 7.22) and direct contact ($p = 0.025$, adjusted OR=3.10, 95%CI 1.15 – 8.33) to be the strongest independent predictors.

Conclusion

3D imaging is useful for predicting the risk of postoperative IAN impairment before surgical removal of impacted lower third molars.

The low IAN impairment rate seen in this study - when compared to similar selected study groups in the literature of the pre-3D-imaging era - is indicating that the availability of 3D information is actually reducing the risk for IAN impairment after lower third molar removal.

Introduction

Surgical removal of impacted third molars is a regular, maybe even the most frequent, procedure in oral and maxillofacial surgery. Damage to the inferior alveolar nerve (IAN) is a typical complication of the procedure. Susarla and Dodson stated that nerve damage following third molar surgery happens in 1 - 22% of surgeries [1]. Different factors have been discussed in the literature as causes of nerve damage: e.g., age of the patient, inexperience of the surgeon, or deep impaction [2-4].

Several authors have described radiological signs that indicate a close relationship between the lower third molar and the IAN in conventional [5] as well as in three-dimensional (3D) [1, 6-8] radiography. Since the development of computer tomography (CT) in 1972 [9, 10], 3D imaging has become more and more routine and has been, of course, used prior to wisdom teeth removal [11]. Nowadays, cone-beam computer tomography (CBCT) seems to be significantly superior to panoramic images in both sensitivity and specificity of diagnosis, resulting in a higher level of intrasurgical safety [12, 13].

The open question remains whether or not the extra radiation dose for 3D-imaging is justified by the information gained. There is no evidence in the literature to date as to whether 3D imaging can predict the risk for IAN damage or whether it does actually lower the risk for patients undergoing wisdom tooth removal or not.

The aim of this study was to identify factors for IAN damage that are detectable by means of 3D imaging before surgical removal of lower third molars.

Method

All surgical wisdom tooth removals performed at the clinic for oral and maxillofacial surgery at the University of Zurich, Switzerland, were retrospectively evaluated for a period of about 11 years, between April 1994 and September 2006. Criteria for

inclusion in this study were impacted lower third molars, projection of the tooth over the full width of the IAN in panoramic radiograph, 3D imaging prior to surgery, surgical removal performed by a board certified oral or maxillofacial surgeon, and complete follow-up, including documentation of pre- and postoperative IAN function. Complete follow-up was defined as sessions occurring at least 3 weeks after the surgery and, if nerve impairment had occurred, until the patient had recovered. Any impairment lasting longer than 6 months would have been classified as permanent. Under these criteria, 515 lower third molars in 293 patients qualified for the evaluation. Excluded cases were also evaluated if any nerve damage was documented. As far as known out of the documentation all teeth had been removed via lateral approach and buccal flap.

The 3D imaging for all included teeth were reviewed by two observers and evaluated for the following criteria:

- Spatial relationship between tooth and IAN:
 - o IAN lateral
 - o IAN lingual
 - IAN lingual without perforation of cortical plate
 - IAN lingual with perforation of cortical plate
 - o IAN between apically open roots (inter-root IAN course)
 - o IAN inside apically closed roots (intra-root IAN course)
- Distance from IAN to tooth: direct contact vs. cancellous bone in-between
- Diameter of IAN canal: constant diameter vs. obvious reduction of diameter
- Maturation: fully formed roots vs. immature roots
- Type of angulation (vertical, mesial, distal, horizontal, transversal)
- Number of roots
- Side

The postoperative IAN function as documented in the patient's chart was evaluated for impairment (permanent or temporary) or full function on postoperative consultations.

The study design fulfills the criteria of paragraphs 4a and b according to the guidelines (version 21.5.2010.2010) of the cantonal ethics committee of Zurich and therefore is exempted from institutional review board approval. The study design thereby fulfills the guidelines of the Declaration of Helsinki about Ethical Principles for Medical Research Involving Human Subjects.

Univariate logistic regression analysis was applied in a first step to identify the factors predicting postoperative nerve impairment and to compute the odds ratio (OR) for each factor including the 95% confidence interval (CI). Influence was accepted as significant if $p < 0.05$. Afterwards a forward stepwise logistic regression analysis was computed for the identified predictors to find associations between them and to provide adjusted odds ratios. The results were crosschecked with a backward stepwise logistic regression analysis. All statistical analysis was performed with PASW Statistics 18 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The female-to-male ratio was 156 (53%) to 137 (47%) for patients, and 294 (57%) to 221 (43%) regarding the teeth. The left to right ratio was 266 (52%) to 249 (48%)

At the first postoperative consultation—which was usually one week after surgery—47 (9.4% of 515) removals had resulted in an impairment of IAN. In no case was the damage permanent over a follow-up period of longer than 12 weeks. Among the excluded cases there was no documented nerve impairment. No case was excluded due to incomplete postoperative follow-up.

An overview concerning the frequency of the evaluated factors in the main group as well as in the subgroups (those with and without postoperative nerve impairment) is given in Figures 1 and 2. Figure 1 shows factors regarding the anatomy of the nerve canal. Figure 2 gives the factors relating to the tooth configuration itself.

Binary logistic regression analysis revealed the distance between the IAN and the root as a risk factor for IAN impairment. If there was no identifiable cancellous bone between the IAN and the lower third molar, the risk for IAN impairment did rise ($p=0.0008$, $OR=5.05$). Also an observable narrowing of the IAN canal in the 3D imaging was leading to an elevated risk ($p<0.0001$, $OR=4.95$).

For statistical testing of IAN courses the buccal IAN position was set as reference, since it was the most common anatomy (50.5%). An intra-root course was responsible for a higher rate of IAN impairment ($p=0.003$, $OR=9.96$). A lingual IAN course was raising the risk of IAN impairment, no matter if in combination with a perforation of the lingual cortical plate ($p=0.0013$, $OR=6.64$) or not ($p=0.007$, $OR=2.72$). Interroot course was short of being significant with $p=0.054$ ($OR=2.93$).

Regarding the tooth and its root configuration, only the factor of fully developed roots was significant ($p=0.045$, $OR=4.36$) for an IAN impairment.

The multivariate forward stepwise regression analysis revealed narrowing of the IAN canal ($p=0.0001$, $OR=3.69$) and direct contact between nerve and roots ($p=0.025$, $OR=3.10$) as independent influence factors. Further analysis showed a close association between these two factors and the risk factors of IAN course. (Table 1)

An overview of all factors, their p-level, OR and the according 95% confidence interval (CI) is given in Table 2.

Discussion

Aim of the study was to identify predictors that lead to an increased risk for IAN injury. A number of them were identified and two of those were independent in multivariate analysis.

Narrowing of the IAN canal raises the risk for postoperative IAN impairment. with an adjusted odds ratio of 3.69. This information is new to the literature and the evidence ($p=0.0001$, 95% confidence interval=1.88 – 7.22) is strong.

The absence of cancellous bone between nerve and tooth or in other words a direct contact between the two structures is another independent factor. This was to be expected from the literature [12, 14] and our study in addition shows the factor to be independent of other findings and quantifies the risk with an adjusted odds ratio of 3.10.

We know from conventional radiography that situations suggesting a close nerve-tooth relationship have a higher risk for postoperative nerve impairment. But literature shows that the relationship cannot safely be judged in panoramic imaging.[6, 7, 12, 13]

Interestingly there is a significant rise in IAN impairment from the lingual course of the IAN canal in relation to the lower third molar. Jhamb et al.[12] reported this before. Since the situation of the nerve in a lingual position is not so rare this is a clinically important finding. We were able to calculate the odds ratio.

Next to the lingual course univariate analysis found more factors that are predicting postoperative IAN impairment but could not have been shown as independent. Basically all IAN positions other than buccal raise the risk even if inter-root course was short of being significant ($p=0.054$). This is clinically important because course of IAN is easy to judge in 3D imaging and for reasons of surgical technique always assessed by the surgeon. However we could show that IAN

position has a close association with the above mentioned two independent predictors of direct contact and narrowing of the IAN canal.

From a surgical point of view it can be derived that a different surgical approach (e.g. a lingual flap) cannot influence the rate of nerve impairment, since the independent predictors are not sufficiently addressed by this change of surgical strategy. On the other hand the knowledge about the exact location of the IAN bundle is a very important one since this information provides knowledge about regions safe for quick removal of bone and danger zones where special care has to be taken.

The study showed that fully developed roots raise the risk for postoperative nerve impairment. This was to be expected since fully developed roots are likely to have a closer contact to the IAN bundle. Consequently this risk factor could not be shown to be independent. However, among other known reasons—e.g., postoperative swelling and pain—this is another argument for early removal of wisdom teeth.

This study could not confirm the influence of side as reported by Baqain et al. [3]. Mesial angulations were suspected by Miloro and DaBell[15] as a factor for postoperative paresthesia of the IAN, mainly because of a closer vicinity of the teeth to the nerve, which had been shown in their previous study. The presented data does not support this since no angulation type showed up as a predictor.

Since no cases had to be excluded due to insufficient follow-up, the impairment rate of 9.4% is realistic. This rate is in accordance with the existing literature in which, e.g., Genu and Vasconcelos reported a rate of 8% in 50 teeth [16]. However, the rate of IAN impairment is difficult to judge because of variations between 1 and 22% due to different inclusion criteria for teeth [1]. Another difficulty is the different level of surgeon experience in the different studies, which has been shown to be a factor in different postoperative complications, including nerve paresthesia [17]. In sum, one has to be very careful when comparing complication rates within different studies.

However, earlier 2D imaging studies that focused on a situation comparable to our inclusion criteria of “projection of the tooth over the full width of the IAN in panoramic radiograph” show complication rates of between 15 and 25%[14, 18, 19]. Therefore, we believe that 3D imaging lowers the risk under the given selection bias of “high risk” panoramic radiography of this study. To be absolutely certain about this a control group without 3D imaging would be essential but is in our eyes not applicable due to ethical concerns. Of course there are several more factors that need to be controlled in such a study — e.g., experience of the surgeon.

After all we believe that the level of almost 10% postoperative nerve impairment is resulting out of the combination of selection bias due to strict inclusion criteria which raises the risk and 3D imaging which might lower the risk by the means of e.g. adapted surgical technique or – in an institutional setting – assignment of a more experienced surgeon.

The basic weakness of this study is the retrospective character itself. There might be a selection bias that cannot be judged retrospectively. Regarding any modifications of the surgical approach due to 3D imaging results there is no detailed information available. We suspect that “risky” patients have assigned to more experienced colleagues and that the indication for separation of a tooth was expanded based on e.g. a close relationship. Also modifications of approach and degree of bone removal might have been performed. However, the study design was not able show that these patients were operated on with special care or by an

especially experienced surgeon. We believe that these disadvantages are outbalanced by the high number of analyzed teeth and by the clear statistical results.

Interestingly enough, the predictors raise the risk, despite the prior 3D imaging and the consecutive knowledge about the situation. On the other hand, any permanent lesion was avoided.

Overall, the exact evaluation of risk factors is important in information for patients, especially concerning individual risk assessment and decision making. It may also lead to different surgical approaches: e.g., coronectomy for high risk cases as described by several authors in recent years [20-24].

Conclusion

This study provides data about a number of factors raising the risk of IAN impairment after surgical removal of inferior third molars

Regarding the overall rate of postoperative IAN dysfunction, this study shows low impairment rates when compared to the literature of the pre-3D-imaging era. The authors believe this is due to the integration of 3D information into the surgical strategy. When risk factors are detected or cannot be excluded in conventional two-dimensional radiography, 3D imaging is justified to improve risk assessment and surgical decision making. Especially patients meeting any of the known criteria as diversion of the IAN canal, darkening of the root where the IAN canal crosses and apparent interruption of the white line bordering the IAN canal where it crosses the root might benefit from 3D imaging. Moreover, the legal demand for more detailed information in groups of higher incidence of potential complication is met and automatically documented by the imaging study.

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Conflict of interest

The authors declare no conflict of interest.

Captions

Figure 1 Frequency of evaluated factors regarding the IAN canal in the overall group and in the subgroups with and without postoperative IAN impairment.

Figure 2: Frequency of evaluated factors regarding the tooth configuration in the overall group and in the subgroups with and without postoperative IAN impairment.

Factor		IAN position				
		Buccal	Inter-root	Intra-root	Lingual without perforation of cortical plate	Lingual with perforation of cortical plate
Total		272	39	9	175	20
Narrowing of IAN canal	Applies	44 (16.2%)	19 (48.7%)	7 (77.8%)	86 (49.1%)	17 (85%)
	Expected in 33.6%	91.4	13.1	3.0	58.8	6.7
Direct contact between nerve and root	Applies	136 (50%)	36 (92.3%)	9 (100%)	135 (77.1%)	18 (90%)
	Expected in 64.9%	176.4	25.3	5.8	113.5	13

Table 1 Association between risk factors. (Percentages are calculated as percentage of the number of teeth with the specified inferior alveolar nerve (IAN) position.)

Factor	Applies in teeth without IAN impairment (of a total of 468)	Applies in teeth with IAN impairment (of a total of 47)	Univariate logistic regression analysis		Multivariate forward stepwise regression analysis	
			p	OR (95% CI)	p	OR (95% CI)
Narrowing of IAN canal	141 (30.1%)	32 (68.1%)	<0.0001	4.95 (2.60 - 9.42)	0.0001	3.69 (1.88 – 7.22)
Direct contact between nerve and root	292 (62.4%)	42 (89.4%)	0.0008	5.05 (1.96 - 13.0)	0.025	3.10 (1.15 – 8.33)
Fully developed roots	392 (83.8%)	45 (95.7%)	0.045	4.36 (1.04 - 18.4)		
IAN position			0.0013			
Buccal IAN position	259 (55.3%)	13 (27.7%)	-	1 (reference)		
Inter-root course of IAN	34 (7.2%)	5 (10.6%)	0.054	2.93 (0.98 - 8.73)		
Intra-root course of IAN	6 (1.3%)	3 (6.4%)	0.003	9.96 (2.24 - 44.4)		
Lingual IAN position without perforation of cortical plate	154 (32.9%)	21 (44.7%)	0.007	2.72 (1.32 - 5.58)		
Lingual IAN position with perforation of cortical plate	15 (3.2%)	5 (10.6%)	0.0013	6.64 (2.09 - 21.1)		

Table 2 Factors influencing the risk of inferior alveolar nerve (IAN) impairment

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